VALUES IN HIGH SCHOOL MATHEMATICS.[1]

There is no need of telling those here present that mathematics is in a rather precarious state at the present time in the field of education; the educational iconoclast has declared that we shall teach what the child likes and not what the child needs: and as a result we have a declaration of purpose to practically eliminate mathematics from the subjects of study in our schools. True, a pupil may elect mathematics if he or she wish, but I believe that when mathematics ceases to be obligatory in the high school, and a diploma may be had with no knowledge of mathematics, we may look to a very near future when comparatively few will be studying mathematics.

Since the sciences, physics and chemistry, rely so much upon at least a fundamental knowledge of algebra, geometry and even trigonometry, they too will suffer from the passing of mathematics.

It seemed to me a very apt time to take up this question before this convention and endeavor to show the value of mathematics in a high-school course, so that we may go forth determined to fight for the retention or, mayhap, re-introduction of mathematics as a required subject in every high-school curriculum. The National Committee on Mathematics Requirements would seem to desire that two years of mathematics be required for a high-school diploma, and we may align ourselves with them and see what would be the value of these two years of required mathematics.

I think we are pretty much of one mind in regard to the value of mathematics in education. Who can judge more surely of the educational value of a subject than those who have spent years in studying and teaching that branch? The value of mathematics in a high-school course and the making it obligatory for all pupils would seem to me to hinge upon the more fundamental point as to what is the chief or primary purpose of a high-school course. If it be to give "culture,"

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the cultural subjects should and must predominate, and only so much of "informational" studies will be admitted as is absolutely necessary. Moreover, even these must be so taught as to bring their own proper "cultural effects" to a maximum. Here I might pause to make clear my terms and avoid possible misunderstanding. By the "cultural" value of a subject, I mean the development of broad views and power of generalizing; arousing of mental alertness and eagerness; development of initiative and self-reliance in forming judgments and meeting difficulties. The fine arts in particular develop correct taste and appreciation of beauty. "Cultural" effects thus include all that tends to modify a student's point of view and habitual way of thinking.

The "disciplinary" value of a subject consists in the training of memory, drill, development of habits of accuracy, neatness, persistence, application, and logical (deductive) thinking.

Thirdly, the "informational" value is the acquirement of knowledge of useful facts, laws, events, theories; as in geography and physics or history taught by recitation from the text-book.

These values often overlap. But modern pedagogy has outlined these values and we take them as put. I need hardly state that the universal belief and conviction of educators is that the prime purpose of a high school is to give culture, not information. Discipline and information hold or should hold secondary places in the aim of a high-school course. True, there are institutions of high-school rank in which information and not culture is paramount; and even here the ideal striven after is to vitalize utilitarian work in every way and make it, so far as may be, cultural and power-giving. An immediate result of this view of the high school is that it becomes necessary to define the precise cultural effect inherent in each branch of the curriculum, and to lay down methods of teaching, which shall make it contribute this effect in the maximum degree, without losing aught of its informational and disciplinary value. And if mathematics be made an obligatory study, at least for one year, in every course in the high school, then we must show that algebra and geometry contribute to the primary end of a high school in such wise

that, to dispense with them in favor of any other branch, would be to defeat the very purpose of high-school education. It is for us to show that algebra and geometry do contribute chiefly to culture as high-school subjects.

Not long ago, there were those who thought and maintained that the "disciplinary" effect was chiefly, if not the only thing worth while in mathematics; emphasis was laid on the drill, the training in deduction and the habit of rigid logic. Undoubtedly, this is one of the important values of mathematics as a high-school study, but much more can be done with it than that. Under one teacher an algebra or geometry class is interested and enthusiastic, and grows in ability and self-reliance each day; under another teacher, the algebra hour is dull and wearisome, the pupils' minds are deadened by drudgery in an alphabetical treadmill, and they learn chiefly this: to abhor for the rest of their lives the very name of mathematics. In such a class the "disciplinary" value of algebra and geometry is being emphasized to the neglect of the "cultural." I feel justified in stating that very few boys or girls, who enter high school, have a natural want of aptitude for mathematics; they do not naturally hate it; but if it be made a bore to them, they will grow to abhor it. Would it not seem that the method or mistaken viewpoint taken in teaching high-school mathematics, is to be rejected and criticized as of no value, rather than the subject itself? The best food in the world can be spoiled by a poor cook.

Mathematics can be so taught as to arouse interest and leave pleasant memories of the time spent in its study. Mr. C. Godfrey wrote, some years ago, in answer to one who styled mathematics a blighting shadow of youthful days: "High manipulative dexterity is not the purpose sought; this belongs to a specialist." Just so, a pianist must spend an astonishing number of hours at mere mechanical technique. But the average man finds no occasion for algebraic calculation, and if he does, the opening is declined in spite of the heavy work that darkened his school days—perhaps because of it. But we are profoundly convinced that the general mathematical ideas and modes of thought wrought into the mind by a suitable course of instruction are of permanent cultural value; these are a

necessary element of a liberal education; whereas dexterity in manipulation is a specialized, technical accomplishment, like glass-blowing, or Latin verses, or playing piano, or shorthand —all very excellent but not necessary to liberal education.

Objection is made that we sacrifice mental and moral discipline by removing merely mechanical drudgery, and giving the pupil *new ideas* instead; but experience refutes this. We still have drudgery but it is vivified by a purpose and a sense of progress. Just as a man walking in a treadmill gets mechanical exercise, so a man walking in the park gets the same, —but, one is, moreover, refreshed and exhilarated mentally, while the other is only wearied and dulled after his purposeless toil.

Let us now turn to the specific subjects our report deals with for the first years of high school,—algebra and geometry, and see what is their cultural effect, their importance.

First, algebra, if exacted strictly—no matter how taught—will produce a "disciplinary" effect on the character, in so far as the pupil has to drive himself to do what he does not like; he learns self-control and the faculties are drilled. These effects, being common to *all* studies whatever, and even to mere physical labor, are not of present interest. If algebra did only this for a pupil, I see no reason why it should occupy a place in the high-school curriculum above any other branch.

Algebra always gives, in the second place, a certain amount of information to a pupil, the utilitarian value of which, in his future life, is negligible. Some few pupils will adopt a career in which algebra is turned to use, but these are hopelessly outnumbered. We may safely put down zero as the informational value of algebra to the average pupil. Here again no reason for making all take algebra in their high-school course.

Algebra, therefore, if it is to give anything of lasting value to a pupil, must give it in virtue of the "manner in which it is taught"; the pupil must be "changed" in some way by this study and get from it a certain power, inquisitiveness, self-reliance, directness of thought, which he had not before and which he could not readily get otherwise. In other words, algebra contributes to culture, to the primary end of a high-school course and directly, for:

1. A pupil in solving exercises or problems learns to muster his resources and use them independently; he acquires self-confidence in attacking or circumventing difficulties, learns to think correctly, learns how to test and check his conclusions when in doubt; he gains faith in his own powers and his originality develops.

2. The "symbols" form a new language very condensed, and idiomatic; the pupil learns to translate to and from these and again acquires self-confidence and power.

3. The habit of "generalizing" gradually grows upon him and gives him broader views and the power of grasping and subordinating details.

4. Incidentally the pupil is acquiring habits of mental accuracy and of concentration of mind upon one point.

5. The "sense of satisfaction" in discovering new things or solving hard problems makes him eager to try his powers on other difficulties independently; it becomes a game in which he is intensely interested and his self-reliance continually grows day by day.

This widening of the student's grasp of universal ideas, of learning to include many differing cases under one heading, namely, the habit of generalizing, is one of those habits which is *transferable* to other lines of thought. We all know what a debate has been raging for years in pedagogical text-books on this point of "transferability of habits." Algebra, if taught inductively, not didactically, produces this effect in the pupil.

The "informational" value of geometry is, in most cases, nil. The "cultural" effect is twofold in its origin; we have:

1. "Problem work, original exercises," the result of which is to cultivate the student's self-confidence, independence, skill and resourcefulness. He learns to separate the essential from what is irrelevant; he learns to construct continuous chains of reasoning; and, finally, to be precise and accurate in thought and speech.

2. He comes in contact continually with explicit syllogistic reasoning, the beneficent effect of which is far reaching. Above all, geometry arouses and brings into play the "detective-instinct." A few clues are afforded in the statement: the pupil must now be a sort of Sherlock Holmes and figure out

the whereabouts of the unknown answer, and rig up an air-tight proof for it. This faculty is again, transferable; so that a year of detective work in geometry will make a pupil more expert in using detective-methods in law or medicine or any other line of work, even commercial.

The importance, then, of algebra and geometry in a high-school course would seem to be paramount. They tend to promote directly and effectively the primary end of the high school—give culture to the pupil, and they would, therefore, appear indispensable to the training of every pupil.

Should we not, then, exert ourselves to bring this importance of mathematics in the education of the young before the great public; to enlighten parents who may fail to realize the value of mathematics and whose duty it is to see that their education is properly given? Should the election of mathematics be left to the young pupil, how many thousands the country over will be governed by ease of acquirement, and choose some branch which makes for little compared to the development mathematics surely gives?

In St. Louis, mathematics is an elective in five out of the seven courses open to high-school pupils. We are banded together in the Mathematics Club of High School Teachers of Mathematics and are waging a determined battle to bring mathematics back into the course as a required subject for at least two years. Business men have already written letters to the newspapers urging the need of mathematics for every high-school student, and the light of publicity is being focused upon the loose arrangement whereby the inexperienced pupil is allowed to choose what often taxes the judgment of a mature mind—the election of subjects which best fit him for future life.

It is our hope that the members here gathered from many schools and cities will see fit to approve our determination and spread to many cities what we wish to bring about in St. Louis,—that mathematics regain its place in a high-school course, as a required subject, because it is a most important element in the proper carrying out of the end and purpose of high-school training.

Rev. W. J. Ryan.

St. Louis University,
St. Louis, Mo.